# The Effects of Machine Errors in Dielectric Loaded Accelerating Structure

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## Abstract:

There is a big difference between the simulation results and HP analyzer cold test results for the S parameter of our new dielectric loaded traveling wave accelerating structure. Usually, these differences are caused by machine errors and the differences between the EM model and its' implementation. The purpose of this work is to identify the causes and find a way to minimize their effect.

## The Problem:

As shown in figure 1, the EM model of the whole structure is consist of a dielectric loaded tube($\varepsilon r=9.4$), two dielectric taper($\varepsilon r=9.7$) and two TE-TM coupler.
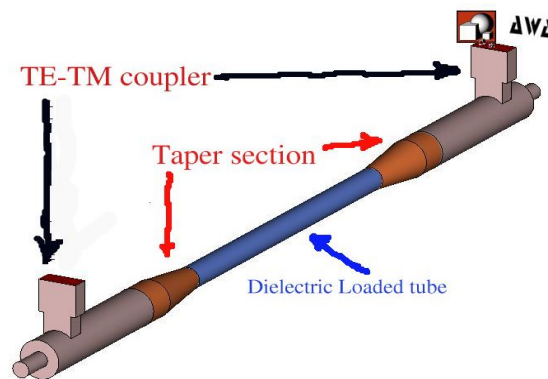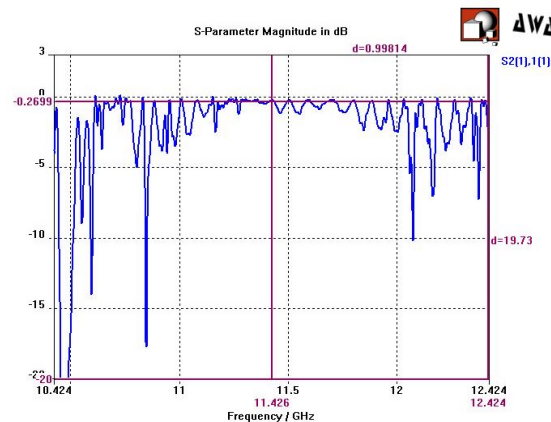


Figure 1. EM model of the whole structure.



Figure 2. S21 of the whole structure from EM simulation

The S21 of the whole structure from EM simulation is given in figure 2 and the HP anayzer result is given in figure 3. As shown in figure 3, the S21 from the cold test is about -3dB. But the EM simulation result is about -0.27dB.

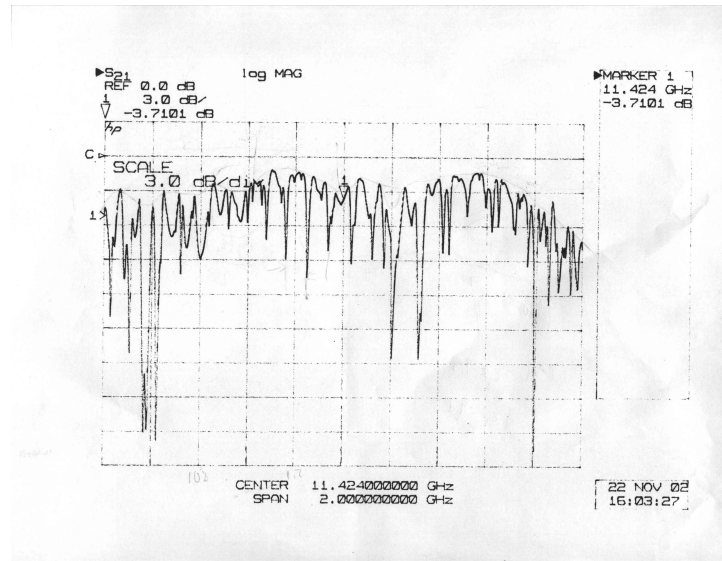

Figure 3. HP analyzer result, S21 of the whole structure

A coupler to coupler test is also done to verify the efficiency of TE-TM coupler. As shown in our previous note, the coupler to coupler results agree well with the EM simulation. This means that the TE-TM coupler is not sensitive to machine errors. The draw back must be caused by the machine errors in taper section and/or the dielectric loaded tube.

As finer mesh is required to model the machine errors, it's very difficult to carry out EM simulation on the whole structure. And also because coupler to coupler test results agree well with EM simulation, we narrowed down the investigation to errors in taper section only.

## Parameters of taper section and its' expected performance

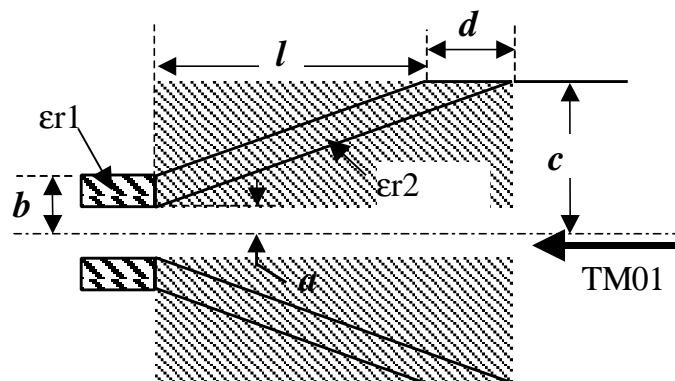As defined in figure 4, the parameters of the taper section are: a=5mm, b=7.185mm,



**Figure 4**. The geometry of taper

$l$=40mm, c=12.079mm, d=l*(b-a)/(c-b)=17.86mm,  εr1=9.4 and εr2=9.7.   The expected S11 of this taper is given in figure 5.
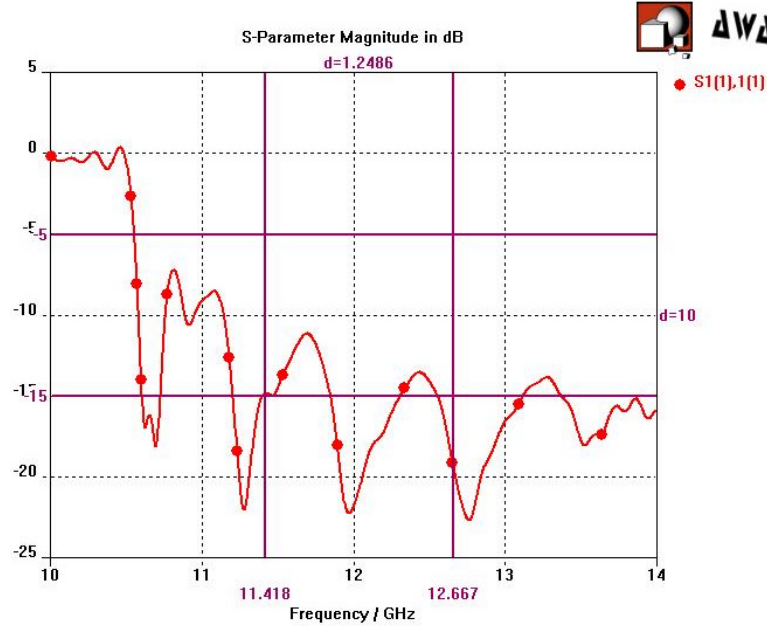


Figure 5.  The expected S11 of the taper section

As the taper section is used to provide matching between circular waveguide and the dielectric loaded tube, errors in taper section may cause severe mismatching in the system.

## Gap between the dielectric

As the dielectric tube and the dielectric taper are made in different pieces, it is possible that there is a very thin gap between them as shown in figure 6.  Two cases of such gap have been investigated with 0.1mm and 0.05mm in width of gap.   The result for the one with a width of 0.1mm is given in figure 7.  From figure 7, we noticed that the S11 is about -8dB at 11.424GHz which is about 7dB above the expected result given in figure 5. When gap width changed to 0.05mm, as shown in figure 8, the S11 is about -15dB at 11.424GHz which is about the same as the expected result.   It is reasonable to assume that the effect will be smaller while the width of this gap decreasing.  So a gap between the dielectric with a width smaller than 0.05mm is acceptable.
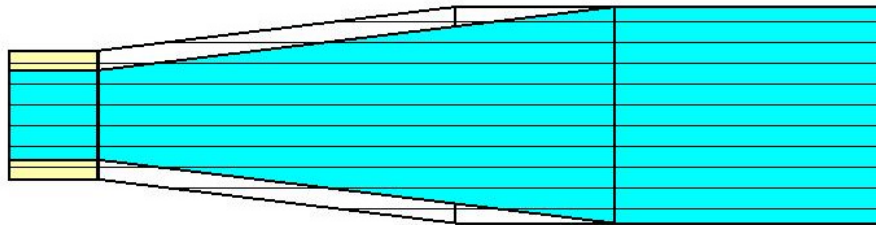
Figure 6.  Gap between dielectric.

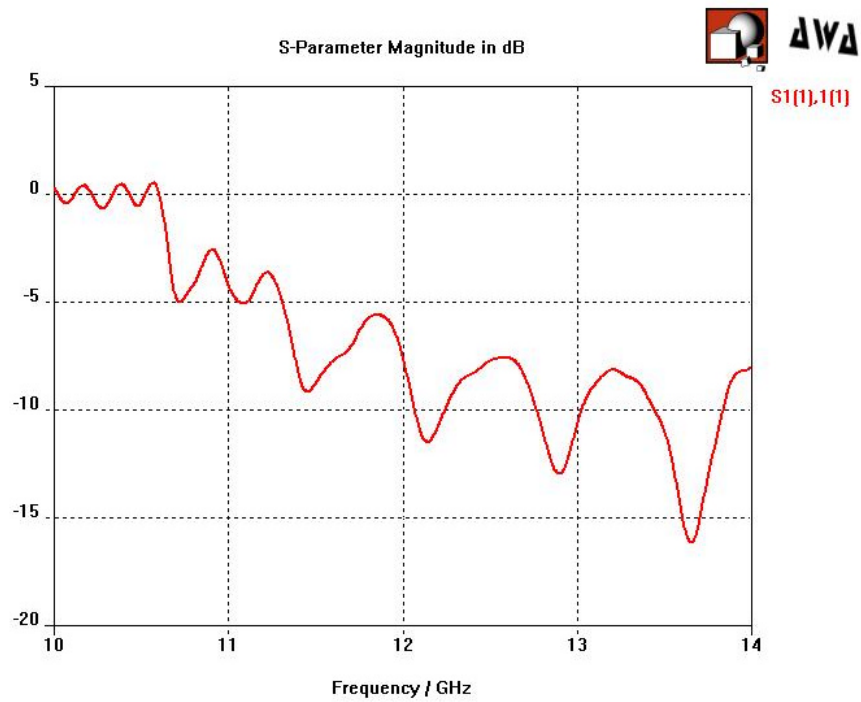S-Parameter Magnitude in dB

S1(1),1(1)

Figure 7. S11 of taper section with air gap between dielectric,
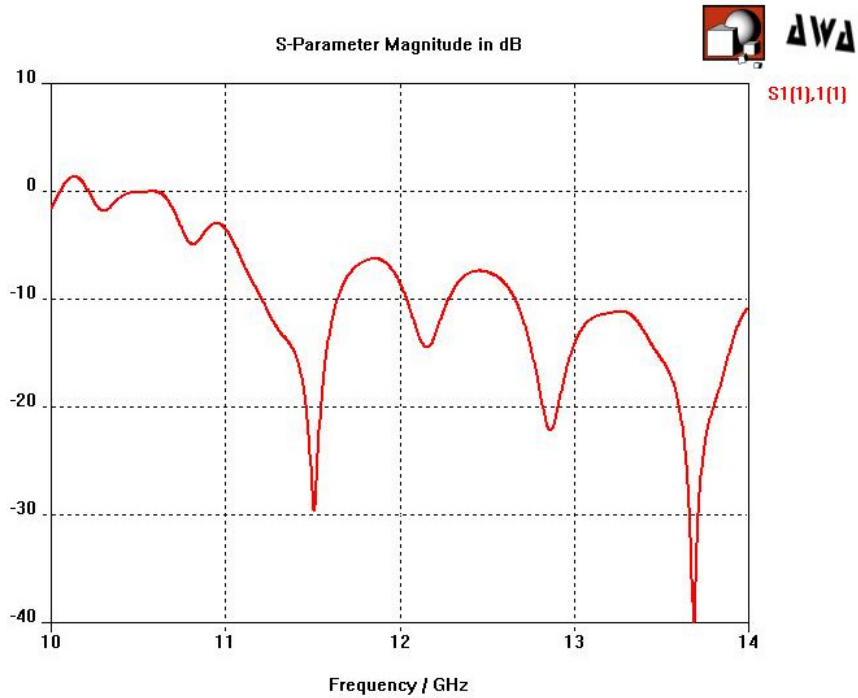gap width=0.1mm.

Figure 8. S11 of taper section with air gap between dielectric,
gap width=0.05mm.

When the gap between dielectric is small enough, it's infuluence to the performance would be acceptable.

## Chamber in the flange

As shown in figure 9, the mechanical drawing of the implementation, there is a chamber in the flange where taper section and dielectric loaded tube join.   Detail geometric parameters of chamber are given as: RGap=22.67mm, RGasket=25.4mm, d1=2.54mm and d2=2.032mm.  The width of gap is assumed to be 0.05mm.  The EM model of this problem is given in figure 10.  Figure 11 gives the curves of S11 under different inner radius of gasket.  This figure shows that as long as the chamber is exist, changing the inner radius of gasket could not improve the matching.  Figure 12 gives the curves of S11 with two different RGap settings.  This figure shows us that changing the radius of the gap could improve the matching dramatically.
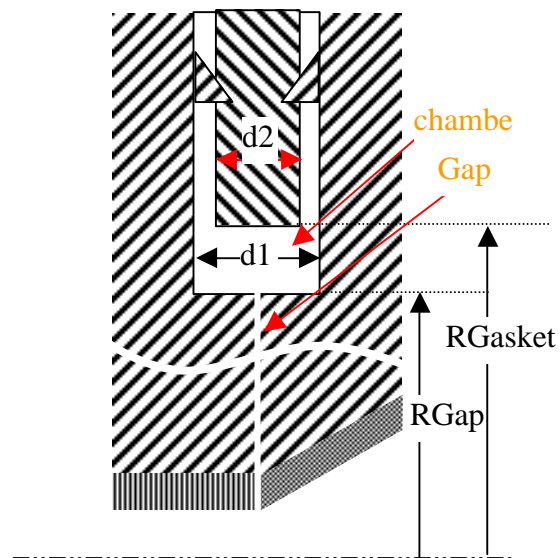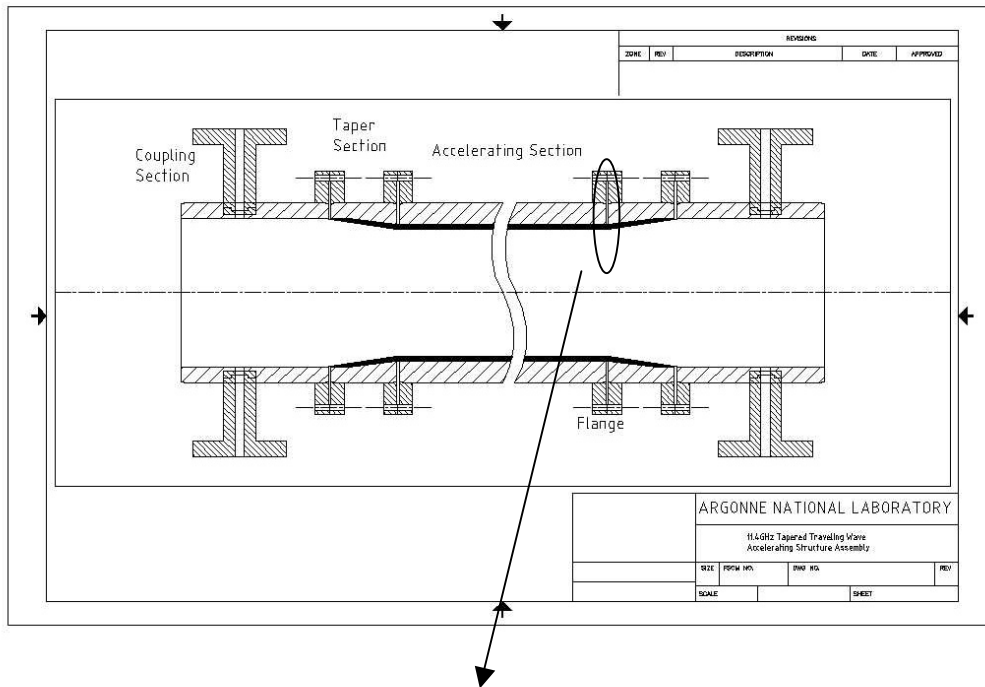
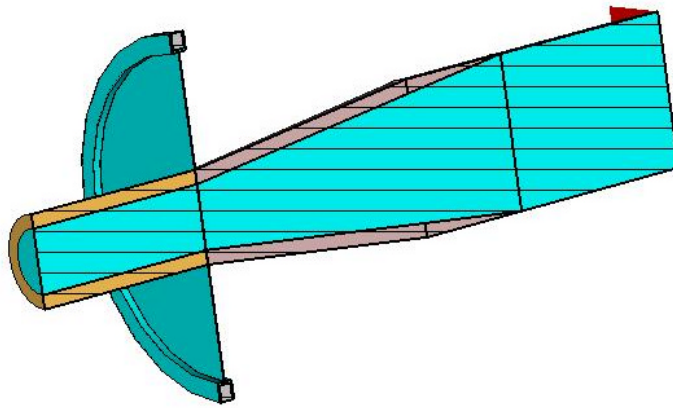Figure 9. Mechanical drawing of the structure.

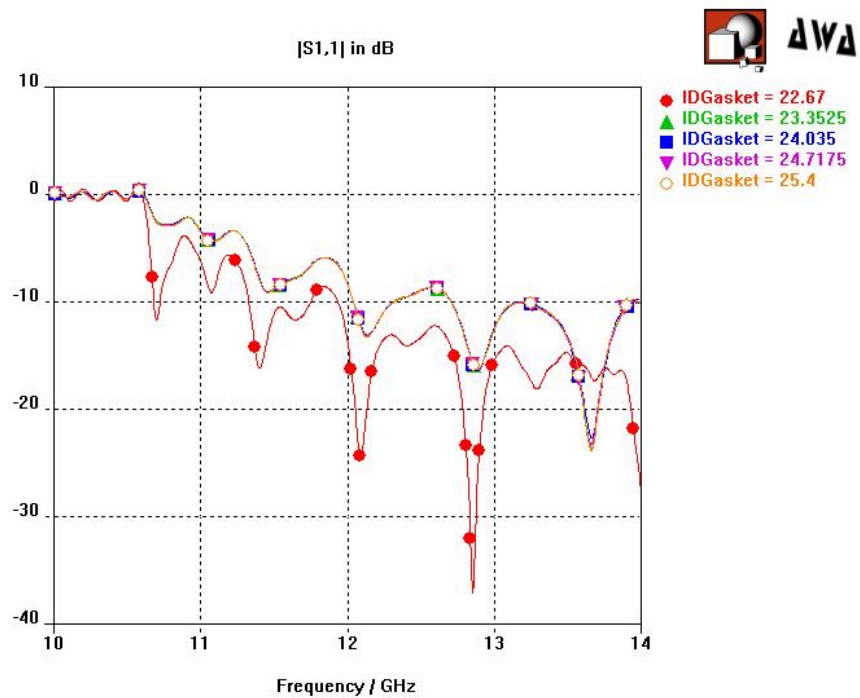Figure 10.  EM model for the taper with chamber in flange



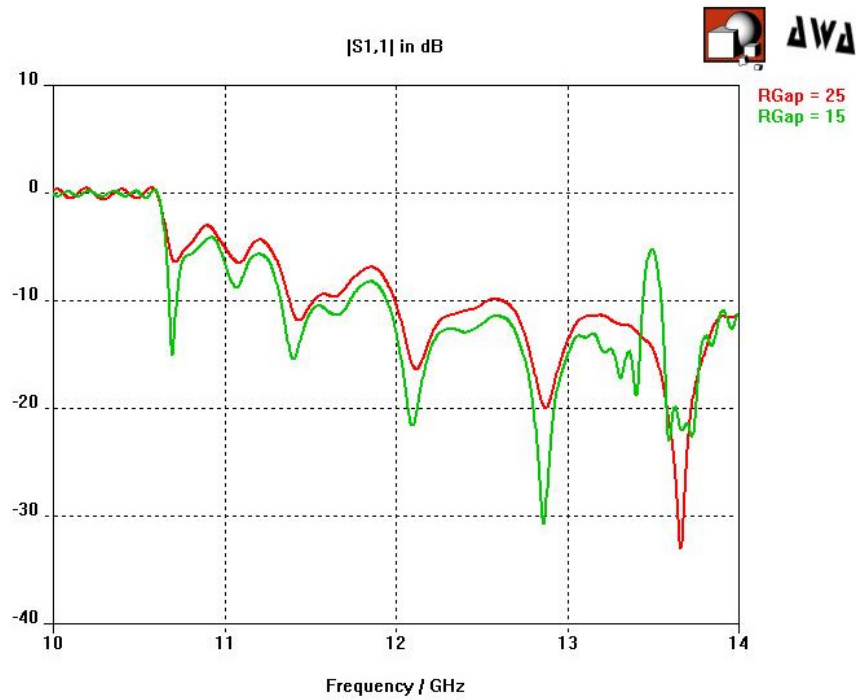Figure 11.  S11 with different inner radius of gasket.

Figure 12.  S11 with different RGap.

Summary:

   Two kind of machine or assemble errors were briefly investigated.  The problems are far more complicated than we discussed here.  The cases discussed here are believed to be of major effect.  According to the results given in this note, some modifications to the mechanical design are needed to improve the performance.  Such modifications may include customized flange and/or gasket.